

Controls on mound formation and effects of fluid ascent on the gas hydrate system of mound structures offshore Costa Rica

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Our analysis of 2D MCS seismic data from the Middle America margin provides an insight into the buildup and formation mechanisms of mound structures and the effects of fluid ascent on the gas hydrate system observed on the continental slope offshore Costa Rica. Our targets, Mounds 11&12, are the sites of IODP drilling proposal 633-Full2, which aims to enhance the general understanding of complex forearc dewatering processes of the erosive subduction system off Costa Rica. Major sites of dewatering planned for drilling are mounds, related to mud diapirism/volcanism and precipitation of authigenic carbonates, and large-scale slides related to the subduction of seamounts.

Geochemical analysis of methane hydrate and chloride anomalies as well as heat flow modeling of the mounds indicate deeply sourced fluids discharged by clay dehydration at the decollement. Hence, the hydrogeological system at this margin appears to be dominated by the fracture porosity of faults which extend through the overriding plate and provide the paths for fluids liberated by early dehydration reactions from the plate boundary.

In order to test the hypothesis of deeply sourced and fault-controlled dewatering sites and to better understand the interactions between gas hydrate formation and dissociation with the fluid ascent from the deep sources, new pre-site survey seismic profiles were acquired using the 36-gun, four-string linear gun array of R/V Marcus Langseth, and a 240 channel streamer with 3000 m of active length. The seismic lines were prestack depth migrated, in which the velocity model is iteratively improved using depth focussing analysis and residual moveout correction on common image point gathers. Improvement of the deep imaging involved multiple attenuation and detailed velocity analysis of the lower sedimentary portions and beneath the basement down to the plate boundary.

Our results reveal an upward bending of the bottom simulating reflection (BSR) directly beneath the mounds, which may indicate a thinning of the gas hydrate bearing layer (GHSZ) probably due to channeled fluid flow and associated hydrate dissociation in the area of the fluid conduit. Thinning of the GHSZ is more pronounced beneath Mound 12 than beneath Mound 11, which corroborates differences in terms of the mounds' activity and stage of development. The obtained depth models show that the mounds are situated above a prominent basement-high which may favour lateral fluid advection as a high-permeability structure. The strong relief of the basement imaged in our data demonstrates that the selected mound sites are both related to deep-reaching fault systems.